The Production of Guidance for the Commissioning and Quality Assurance of a Networked Radiotherapy Department – An IPEM Working Party Approach

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Changes in Radiotherapy Technology in the UK:

Over the past few years, radiotherapy departments across the UK have benefited from the Governments Cancer Plan[1] in terms of renewing and increasing the radiotherapy equipment complement of each centre. This has seen an attempt to replace very old linear accelerators and simulators and provide increased numbers of treatment machines and planning systems for patients. At the same time, it has been recognised that the new equipment supplied should be state of the art regarding multileaf collimation, electronic portal imaging and radiotherapy networking. However such modern techniques rely heavily on large amounts of data and the necessity for electronic data flows and networks. For instance, it is completely impractical to expect operators to input manually MLC position information for a treatment field.

In addition, the latest advances in radiotherapy processes themselves (e.g. IMRT) rely heavily on electronic transfer of both treatment parameters and image data, using DICOM and other protocols. Networking not only facilitates these technological changes in the radiotherapy process, but can also make it more efficient and safer. The types of equipment used in radiotherapy, or providing data for its planning, has grown substantially, and includes:

- Imaging equipment (Radiotherapy Simulators, CT, MR and PET Scanners, Ultrasound equipment)
- Treatment planning equipment (including virtual simulation, image fusion etc.)
- Treatment delivery equipment (superficial XRT, megavoltage XRT, remote afterloading)
- Treatment verification (record and verify systems, electronic portal imaging systems, in vivo dosimetry systems)
- Hospital patient information systems (PAS, EPR, etc.)

Current Guidance:

Guidance for quality control of radiotherapy equipment is available most recently in the form of IPEM Report 81[2]. Guidance on the commissioning of linear accelerators and ancillary equipment (multileaf collimators, EPIDs etc.) is over ten years old[3] and is currently being re-written. However, neither of these documents cover to a great extent the commissioning and quality assurance aspects of the networking systems (and their processes) which interconnect the wide variety of equipment now used in and providing data for radiotherapy. The systems of work and their interconnection are still in their infancy and both commissioning and quality assurance aspects have yet to be considered in any great depth.

History of Working Party:

In 2002, a suggestion was put forward by Gill Lawrence (Newcastle) to the IPEM Radiotherapy Special Interest Group for the basis of a working party to look into these issues. A working party proposal was submitted to IPEM Council and Scientific Committee in March 2002, and it was duly approved in July 2002, with the request to complete the work in 12 – 18 months, because of the lack of current guidance within the radiotherapy community on networking issues.

The working party (consisting of myself, Mr David Carpenter (Southampton), Ms Gill Lawrence (Newcastle), Mr Andrew Poynter (Ipswich) and Mr Paul Studdart (Kent)) had their first meeting in October 2002.

Initial Aims and Objectives:

Following an initial meeting and discussions, a series of aims and objectives were drawn up for the guidance. These included

- To determine if any information or recommendations were currently available regarding commissioning and quality assurance for networks in radiotherapy
- To consult widely with the UK radiotherapy community and manufacturers to gain their opinions and insight for the contents of the guidance
- To produce a guidance document which was as inclusive as possible, covering the different practices within the UK
- To provide frequencies or guidance for establishing frequencies for quality assurance
- To examine specific IT issues such as security, contingency procedures, good network management and administration
- To cover practical details such as configuration and archiving, scheduling the commissioning process and making full use of multi-disciplinary approaches

Parallel Processing:

It was clear from the outset that in order to maintain the momentum of the working party and ensure that it was completed within the desired timescale that some working in parallel was necessary. The approach adopted was to perform the consultation process at the same time as designing the structure of the guidance and doing the actual writing. The results accrued and analysed from the consultation would then feed into chapters in later drafts so that no information was lost. Once an initial design for the guidance had been agreed upon, further help was enlisted to begin the writing process. The co-authors enlisted were Mr Nigel Deshpande (London), Dr Andy Hoole (Cambridge), Dr Keith Langmack (Nottingham) and Ms Julie Massey (Preston).

Consultation:

The consultation process consisted of two questionnaires; one for all the Heads of Radiotherapy Physics Departments in the UK and one to the main manufacturers of radiotherapy equipment. Both were conducted through e-mail.

The Questionnaire to Heads of RT Physics asked for information regarding both operational issues regarding networking and details of the departments network structure. Some of the questions asked were:

- What operating systems are in use?
- Who has responsibility for
  - Network installation?
  - Network administration and maintenance?
  - Routine tasks (e.g. backups, QC tasks)?
  - Design of Qc checks?
- What sort of data is archived?
- What QC checks are performed and how frequently?
- Any comments on the commissioning and QC checks which should be performed for a radiotherapy network?

Questions asked of manufacturers were more open-ended and looked for their views and opinions on, for example,

- Interconnection of RT equipment
- The responsibility of the manufacturer in providing network solutions and communication between equipment
- The IT tools which should be provided by the manufacturer
- The establishment and implementation of DICOM and other network protocols

Design of the Guidance Report:
After much discussion and deliberation, a structure was chosen for the guidance that would have a substantial technical chapter (regarding networking and IT processes) and a series of chapters that followed a generic patient perspective through the radiotherapy process. It was believed that this would present a model that was easy to follow, would enable the user to 'dip' into the chapters which were most relevant for the task in hand (i.e. the process or part of the network being examined) and be as widely applicable as possible.

Chapter	Common 'feel' for each
Introduction	* Introduction to the systems discussed, process diagrams etc. * Specific Data Transfers, such as input and output data considered * Quality Assurance Issues, such as data importance, tolerances and acceptability for clinical use * Commissioning and QA procedures, equipment required and methods using specific examples * Documentation and Contingency Issues
Hospital IT Issues	
Patient Data Acquisition	
Patient Treatment Definition and Planning	
Pre-treatment verification	
Treatment Delivery	
Treatment Verification	

Figure 1: The initial design for the guidance

The initial design for the guidance is shown in figure 1. It shows main subject headings for each chapter and the common approach suggested for each. This would try and maintain a common feel to the guidance. However, authors were allowed to write freely around these general guidelines.

Clearly the overall results from the consultation process and the written chapters will be the Guidance report itself, and it would make this article much too long to recount them in specific detail. So a selection of results will be presented from the completed questionnaires from RT departments and manufacturers, and brief outlines will be given of the various chapters.

Results – the Consultation with Manufacturers
Overall, the response from manufacturers was quite poor – only two replied! As the questions were more open-ended, so their replies are a little bit more difficult to quantify! However, we found that their views were as follows;

- Adherence to industry standard protocols is very important
- Manufacturers should try and provide procedures which demonstrate the correct operation and integrity of the networked processes at the time of acceptance. The user may be encouraged to use these procedures as the basis for more regular quality control tests
- There must be a protection of intellectual property rights when communicating with third party systems, although the interface development benefits from an inter-manufacturer communication and co-operation
- It is the users responsibility for overall network security
- The manufacturer should be able to produce a requirements specification for a network, which the user may follow as a guide

Results – the Consultation with RT Departments
Responses were received from 18 radiotherapy physics departments across the UK (about a third of all the departments). We found that

- In terms of operating systems, most widely used are Windows (98/NT/2000) and UNIX
- Most networks have been installed by the hospitals IT department or a subcontractor, although some have been done by the RT physics department itself
- Most network maintenance and administration is performed within the Radiotherapy/Radiotherapy Physics departments (i.e. NOT by hospital IT)
- Most regular administrative duties (such as backups on the treatment planning systems and EPIDs, etc. are performed by RT Physics. For the Record and Verify or overall Network System, they are performed by both Physicists and Radiographers
- Most quality assurance procedures are performed at the commissioning stage of a network process and thereafter either following software/hardware upgrades and faults, or on a monthly basis (see Figures 2a and 2b). These tend to be designed by RT Physics, but performed by physicists, technologists and radiographers

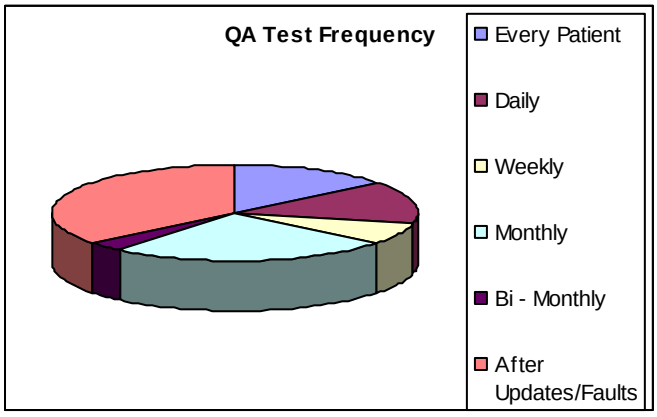

Figure 2a: The distribution of QA test frequencies being performed within some radiotherapy departments in the UK, 2003

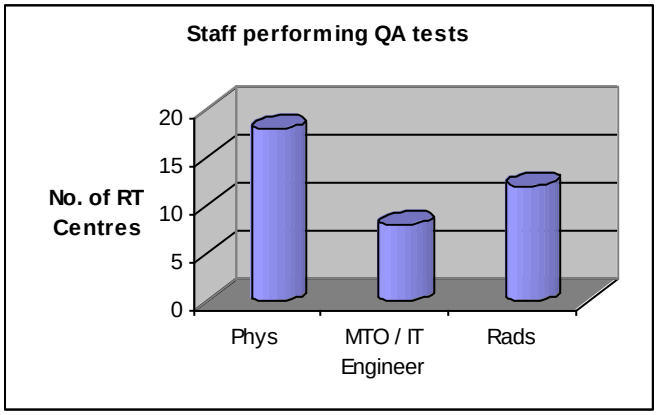

Figure 2b: The distribution of personnel performing the QA tests of figure 2a

The questionnaires also asked to give an outline of the equipment and the electronic interfaces present in each department, including the types of data normally passed and the directions of dataflow. These process diagrams would help to ensure that all authors for the guidance were aware of the current networking situation in the UK and that the guidance would be as inclusive as possible. An example of a typical process diagram received (from the treatment verification part of the Royal Preston Hospital Radiotherapy network) is shown in Figure 3.

Results – Changes to the structure of the Guidance Report
As detailed above, each chapter was being written whilst the consultation process was in progress. From the initial drafts, it

was clear that some changes in the structure of the guidance were also necessary at this early stage. The working party agreed to (a) add the results of the consultation process to the Introduction of the report, (b) add an extra chapter discussing issues common for commissioning and performing quality control on any part of the radiotherapy network and (c) possible appendices to cover items such as essential guide to DICOM and simple networking troubleshooting methods.

Outline details of each chapter

Outlined below are brief details of the contents in each chapter of the guidance report. Clearly, it is not possible to go into great depth in this article; we'll leave that for the report when it is published!

Common Issues

This chapter considers the general issues involved when commissioning or performing quality assurance on any networked process within radiotherapy. These include

- practical management of the network (both technical and working practices)
- preparatory work for commissioning all or part of the network (such as examining the systems involved, their interconnection, the protocols for communication, data flows, the use of process diagrams etc.)
- issues of quality assurance (such as classifying data 'importance', setting tolerances for transfer and defining the limits for acceptable clinical use)
- designing commissioning and testing plans (including using multi-disciplinary approaches, maximising the efficiency of testing using careful scheduling, testing protocols and documentation)
- designing protocols for regular quality assurance and clinical use, in particular where changes in working practices might be involved
- an introduction to DICOM definitions

Hospital IT Issues

The working party firmly believes that one of the strongest parts of this guidance report will be this chapter, where, for practically the first time, typical IT issues are brought to the radiotherapy physicists attention in a single resource. It will include sections on

- Risk Analysis (examining items such as assets, vulnerabilities, attackers and costs)
- Connectivity and network security (for example, configuration, traffic levels, protocols etc.)
- Data security and integrity (backup policies, change control, access permissions, OS vulnerabilities, malicious software, intrusion detection and log analysis)
- Systems compatibility, covering protocols, routing etc.

Patient Data Acquisition

The first of the chapters starting the reader on a generic patient pathway for networking within radiotherapy. It covers workflows such as that showed in figure 4. Here are covered processes from the time of patient referral through to the readiness for treatment planning. Data involved includes demographic data from systems such as HIS, RIS and EPR. Specific data outputs from RT dept. equipment (such as simulators, outlining devices) and equipment outside the department (such as CT/MR/PET/US/NM). Other issues considered are (a) quality assurance for the electronic data (such as integrity of patient identity, image geometry and scaling, orientation and location etc.), (b) commissioning and QA procedures (including phantoms which could be used, and sample procedures for typical system interconnections) and (c) contingency and documentation issues (e.g. alternative transfer paths when the network or part of the network is down).

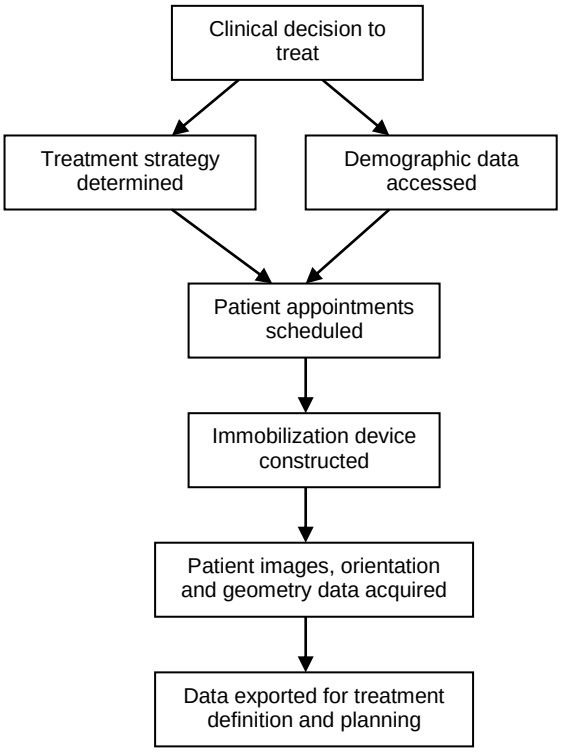

Figure 4: Typical workflow for patient data acquisition at the start of the radiotherapy process

Treatment Definition and Planning

Typical data inputs considered here are images, demographics, structure sets from other systems (such as Virtual simulation (VSim). Data outputs include data from simulators VSim and TPS, DICOM RT objects, output for verification (to Simulator or CT), output for accessory construction (such as a block cutter) and data output for treatment delivery and verification (such as data to Record and Verify Systems, Network Systems and the Linac itself). Quality assurance issues such as the phantoms which could be used for geometry and dosimetry checks and tolerances which are permitted are also considered. Tests are suggested through the use of specific examples, such as data out to a beam shaping device, compensator cutter or DRR transfer to a verification device.

Pre-treatment Verification

Here data input structures considered are demographics, DRRs, planning image data, plan dose data and set-up instructions, and IMRT fluence maps. The expected outputs from typical pre-treatment verification equipment are matching and/or comparison results (e.g. when comparing DRRs with pre-treatment image data). Commissioning planning, tests and equipment are suggested for this part of the network process, between equipment such as treatment planning systems, Virtual simulators, simulators and IMRT software systems.

Treatment Delivery

Typical processes and equipment considered in this chapter are the simulator, Virtual simulator, CT-Sim, Sim-CT, treatment planning system, record and verify systems, Network System, superficial x-ray units, hospital PAS system and Linacs. The data involved is clearly of different types, from demographic to treatment plan parameters to planar and volume images. Many departments have different methods of data transfer, and these have to be considered (e.g. use of removable media as well as DICOM and proprietary protocols). QA issues considered are internal recording of data, electronic transfer to other systems and the integrity of that transfer, particularly for dose sensitive data structures. Equipment is suggested for testing data transfers between systems; for example the use of test prescriptions, MLC templates etc.. Possible problems are

also considered (e.g. differences between internal conventions and different display conventions on equipment, the effect of machine terminations and faults, the transfer of data between treatment delivery equipment)

Treatment Verification
Both geometric and dosimetric issues are considered in this chapter. Treatment verification is one of the areas of radiotherapy which is currently seeing some impressive developments, as it has to in order to ensure that the potential improvements in dose conformation afforded by IMRT are realised to their fullest. This chapter examines standard methods of verification through the use of EPIDs, and the new developments such as Cone Beam CT, In-room CT, In-room Ultrasound, outlining and tracking devices. Test equipment is suggested and sample procedures are described.

Progress so far
The first draft of the guidance was completed in July 2003, with second and third drafts meeting their appropriate deadlines of September and November 2003. It is hoped to submit the final draft to IPEM for review in either Dec 2003 or Jan 2004. This would mean that the working party and additional authors have managed to complete the guidance within 14-15 months of the first working party meeting – within the original timescale requested by IPEM. This is quite an achievement considering that all authors are members of busy radiotherapy departments.

Conclusions
It is hoped that the guidance will provide an ideal reference for departments within the UK and abroad. It will contain invaluable material regarding networks and their management and administration. Additionally it should help the user with establishing and completing commissioning plans for new or expanded parts of the radiotherapy network, and producing quality assurance programs as necessary.

Acknowledgements
The IPEM working party for developing this guidance is Mike Kirby – chair (Preston), David Carpenter (Southampton), Gill Lawrence (Newcastle), Andy Poynter (Ipswich) and Paul Studdart (Kent). The additional authors are Nigel Deshpande (London), Andy Hoole (Cambridge), Keith Langmack (Nottingham), and Julie Massey (Preston).

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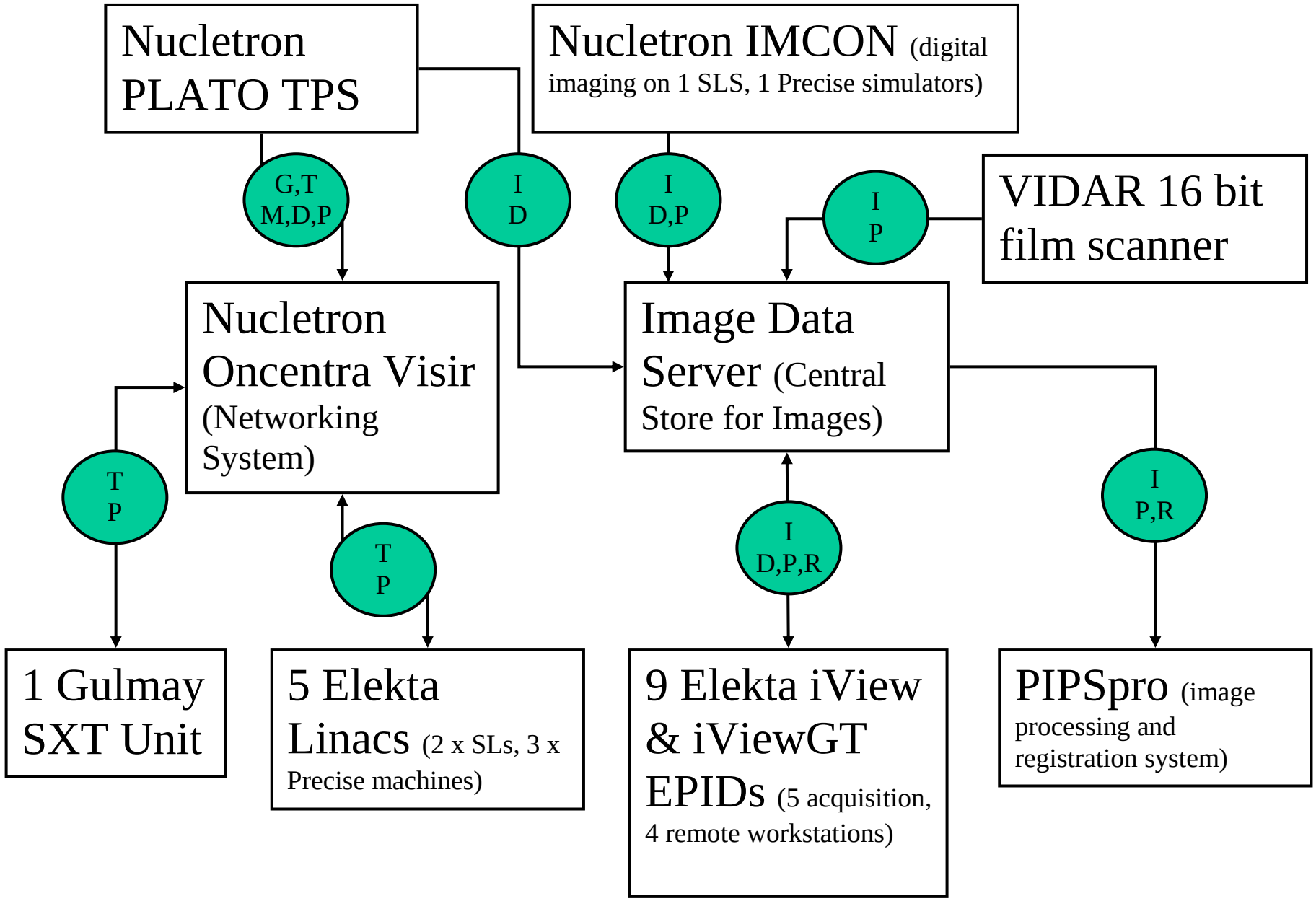

Figure 3: Part of the Process diagram for the treatment verification section of the radiotherapy network at Rosemere Cancer Centre, Royal Preston Hospital, 2003. Shown are directions of data flow, the types of data involved (I-Image, G-General Demographics, T-Treatment Plan Parameters) and the methods of transfer (M-Manual, D-DICOM, P-Proprietary electronic interface, R-Removable media)